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FURTHER NOTES ON FORESHADOWING THE SEVERITY OF THE ICEBERG SEAS--ETC(U)
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WOODS HOLE OCEANOGRAPHIC INSTITUTION

Woods Hole, Massachusetts

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6 Further Notes on Foreshadowing the Severity of the Iceberg Season South of Newfoundland

10 by

I. I. Schell

9 Technical Report 15

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INTRODUCTION

It may be recalled that following the preliminary indications mainly by Meinardus (1904) and Mecking (1906) that the iceberg severity off Newfoundland* in the spring and early summer is influenced by the preceding pressure distribution in the northern North Atlantic and adjacent areas, Smith derived a formula (1931) employing essentially the pressure falls: Belle Isle to Ivigtut and Bergen to Stykkisholm, based on data from 1879/80 to 1925/26, inclusive.

Subsequently Groissmayr (1939) suggested that also the preceding temperatures in the North Atlantic and elsewhere bear a marked relation to the following ice off Newfoundland as, perhaps, might have been expected from the general relation between the pressure and temperature in that area.

The reasoning that may be suggested for the apparent control of the ice off Newfoundland in late spring and early summer by the preceding October-January Bergen to Stykkisholm and the December-March Belle Isle to Ivigtut pressure falls is briefly as follows.

An above normal transport of air into the Arctic denoted by a large Bergen to Stykkisholm pressure difference may be expected to give rise to an above normal outflow from that area, which may be assumed to continue for some time beyond the period of the initial inflow. The outward transport of air probably occurs along several paths, of which the general area of Greenland and Baffin Land, owing to the configuration of the isobars over it, must be regarded as one of the more favored ones; and hence when the outflow from the Arctic actually takes place over this area, it may be assumed to lead to more bergs drifting southward in Baffin Bay and David Strait (west side) and along the Labrador coast, eventually appearing in greater numbers off Newfoundland. In the same way, stronger northwesterly winds that can be assumed to be associated with large Belle Isle to Ivigtut pressure falls, may be expected to prevent some bergs from getting stranded in the inlets and shallows of the Labrador coast and also to speed more bergs southward.

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* For a distribution of the bergs in Baffin Bay and Davis Strait during the off-season south of Newfoundland, see Fig. 1, taken from a paper by E. H. Smith (Bull. No. 30, Intern. Ice Observ. and Ice Patrol, U.S. Coast Guard, Wash., D.C., 1941). The 1940 berg count off Newfoundland was one of the smallest on record, only 2 icebergs being observed the entire season; and it may be presumed that far more bergs could be observed in other years on the North American side of Baffin Bay and Davis Strait and along the Labrador coast.

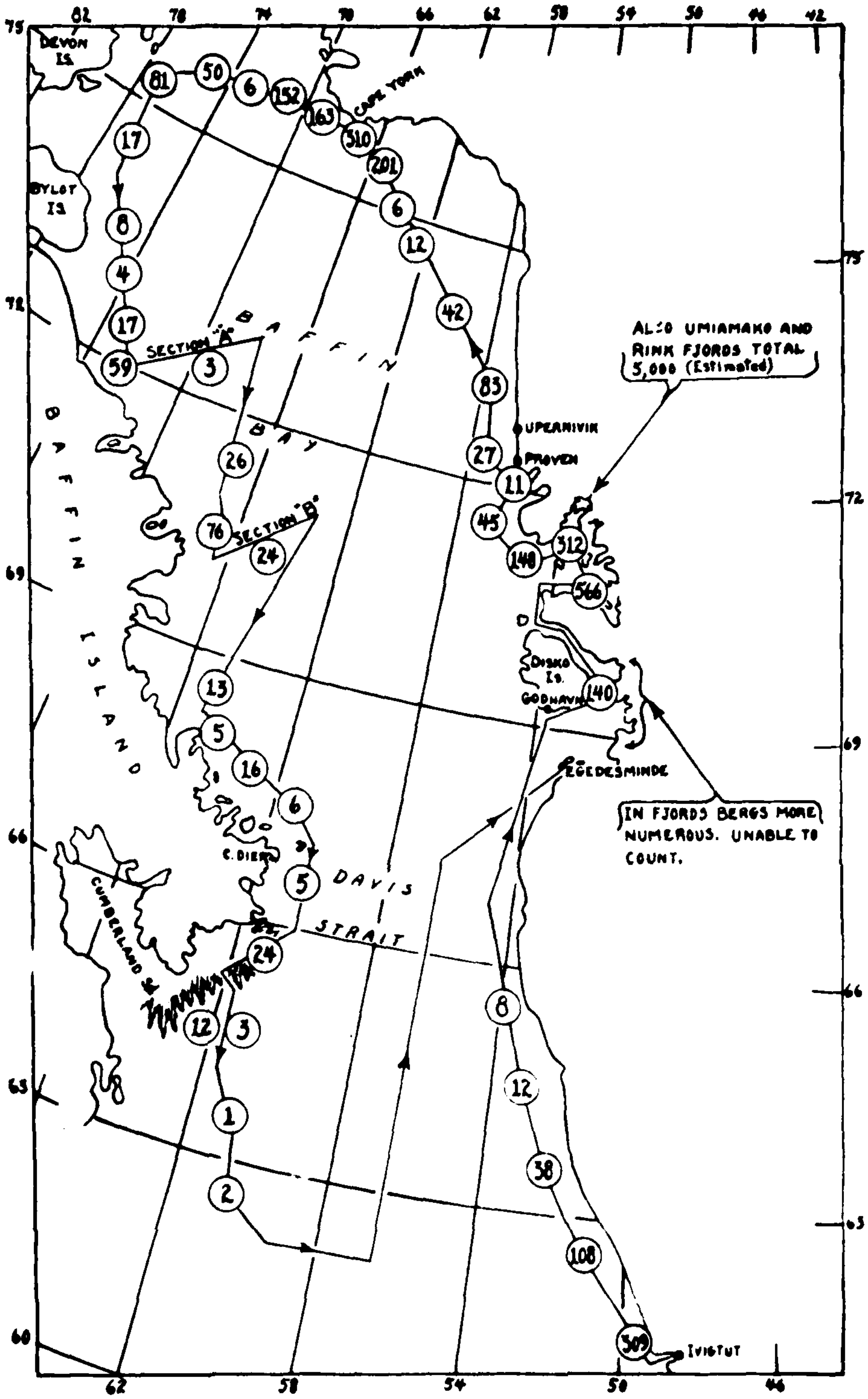

Fig. 1.—Distribution of icebergs in West Greenland fiords, Baffin Bay, and Davis Strait, Sept. 5-23, 1940 (Fig. 4, U. S. Coast Guard Bull. No. 30, Wash., D. C., 1941)

Similarly, when the temperature immediately preceding the iceberg season off Newfoundland is above normal in the general area of Scandinavia and below normal over Newfoundland, both denoting, respectively, stronger southwesterly winds over the northeastern North Atlantic and stronger northwesterly winds over the northwestern North Atlantic, a greater than usual outflow of cold air may occur or is actually indicated, over the general Greenland and Baffin Land area, which would favor a greater drift of bergs along the Labrador coast and eventually off Newfoundland.

A later test by Schell (1940) of the pressures-ice and temperatures-ice relations indicated above, employing the data for the 13-year period: 1926/27-1938/39, that did not figure in the original computations, showed fair agreement between the computed and actual deviations.

FURTHER ANALYSIS

Stability of Relationships

It was recently suggested by Walker (1947), however, from an over-all consideration of the stability of the previously derived relationships by Smith and indirectly by Groissmayr, that these relationships have undergone a marked change presumably due to the marked alteration in the North Atlantic circulation and the general warming up that occurred in recent decades in high latitudes. According to Walker, the coefficients of correlation based on data after 1905 or 1910 differ radically for the most part, from those based on data of earlier years, the general trend being downward.

Walker's findings would seem to require reexamination, however, because firstly, by considering the standard seasons only (D-F, M-M, etc.), he did not consider quite the same combination of months as was done by Smith, for example, and secondly, what may be more significant, while some factors, like Ivigtut pressure for example, were found by him to have weakened in their apparent control of the ice, others, like Bergen, appear to have strengthened, raising the question whether in the combinations used by the earlier investigators there may not have occurred enough compensation, to offset the over-all change Walker's work suggests.

As a test of Walker's findings, correlation coefficients were computed more nearly along the lines employed by Smith and Groissmayr, also utilizing the greater body of data now available (Table 1). The obtained correlation of the ice with the preceding October-January Bergen to Stykkisholm

pressure difference gives, r = 0.30 (1879/80-1948/49, n= 70) and with the December-March Bell Isle to Ivigtut pressure differences, r= 0.53 (1882/83-1948/49, n = 67). Breaking up the periods into havles, however, we obtain for the second half of the period of the Bergen to Stykkisholm pressure difference, r = 0.08 (1914/15-1948/49, n = 35) and for the Belle Isle to Ivigtut pressure difference, r = 0.58 (1916/17-1948/49, n = 33), indicating that while the relation of the Bergen to Stykkisholm pressure fall with the ice has virtually ceased in recent years there has been no real change in the marked relation of the Belle Isle to Ivigtut pressure fall with the following ice off Newfoundland (see Table).

TABLE 1

Relation of Iceberg Count off Newfoundland to the Preceding Pressure Differences: Bergen to Stykkisholm and Belle Isle to Ivigtut, Shown by the Correlation Coefficient, r, for the Periods 1879/80-1948/49 and 1882/83-1948/49, Respectively.

With Bergen - Stykkisholm Pressure Difference			With Belle Isle - Ivigtut Pressure Difference		
Period	n	Oct.-Jan.	Period	n	Dec.-Mar.
1879/80-1948/49	70	0.30	*1882/83-1948/49	67	0.53
1879/80-1913/14	35	0.47	1882/83-1915/16	33	0.44
1914/15-1948/49	35	0.08	1916/17-1948/49	34	0.58

Similarly, a recomputation of the correlation coefficients involving the preceding temperatures at St. John's, Bermuda and Uppsala derived by Groissmayr, based on the data for the 70-year period: 1879/80-1948/49, nowavailable, showed (Table 2) that while the individual relations of the Bermuda and St. John's temperatures with the following ice have undergone a very marked change from the first half of the period (1879/80-1913/14) to its second half (1914/15-1948/49), the over-all relation would appear to be rather stable, the loss of association of the ice with St. John's and Bermuda temperatures during the period 1914/15-1948/49 apparently being to a marked extent compensated by the gain of association with Uppsala temperatures of the same period.

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* Date for Belle Isle prior to 1882 were not available to the author.

TABLE 2

Relations of Iceberg Count off Newfoundland to the Preceding Temperatures at St. John's, Bermuda and Uppsala shown by the Correlation Coefficient, r, for the Period: 1879/80-1948/49.

		St. John's	Bermuda	Uppsala
Period	n	D-F	D-F	March
1879/80-1948/49	70	-0.44	0.34	0.57
1879/80-1913/14	35	-0.74	0.44	0.51
1915/15-1948/49	35	-0.19	0.23	0.63

Pressure Distribution West of Baffin Bay

It was suggested by Walker (ibid.) that the pressure distribution to the west of Baffin Bay, etc., previously impossible to consider for lack of adequate data, plays an important part in determining the number of bergs that drift southward in Baffin Bay and Davis Strait and which arrive in late spring and early summer in reduced numbers off Newfoundland.

With only Pt. Barrow pressures at his disposal, Walker correlated the mean monthly values at that station with the ice off Newfoundland on the assumption that low pressure in the general area of northern Alaska must mean a greater south to north (Pt. Barrow) pressure fall, and hence stronger west winds all the way to Baffin Bay, the stronger winds in turn leading to a greater movement of bergs into the Bay and thence southward along the Labrador coast towards Newfoundland. The coefficient of correlation between the October-November pressure at Pt. Barrow and the following spring and early summer iceberg count off Newfoundland, computed by Walker, is $r = -0.74$ (1921/22-1938/39), $n = 18$), the interval of four months (December to March) between the end of the pressure season involved and the beginning of the ice season being a very rough estimate of time for the bergs from Baffin Bay, etc. to appear off Newfoundland.

It was recently pointed out by the author, however (Schell, 1948), that the prevailing wind at Pt. Barrow during October-November is from the northeast rather than from the west, there having occurred only once (1935) in the 36 years of observation (through 1948) when the prevailing wind was from the west, the wind in all the other years having an easterly component.

Indeed, a correlation of the October-November Pt. Barrow pressures with the following ice off Newfoundland, utilizing the data now available for the periods: 1939/40-1948/49, 1899/00-1920/21, subsequent and preceding respectively, the period: 1921/22-1938/39 examined by Walker, gave, respectively, r = 0.19 and 0.26, indicating an opposed relation to that of the middle period. As a consequence, the over-all association during the entire period of 50 years including the 21 available to Walker, was practically nil (r = 0.09, 1899/00-1948/49, n = 50). The very marked inverse association during the 21-year middle period has been virtually balanced by the direct association during the two end periods.

The lack of control reflected by the pressure at Pt. Barrow during October-November of the ice off Newfoundland the following late spring and early summer does not diminish the force of Walker's suggestion that the pressure distribution in the general area of Baffin Land and Labrador exerts a marked influence on the concentration of bergs in their adjacent waters and their southward drift to the vicinity off Newfoundland. One may conclude only that Pt. Barrow, about 2,000 miles to the west, does not reflect the pressure distribution that affects the southward drift of bergs to Newfoundland but that one must consider the conditions or, whenever possible, the actual winds in the areas of the iceberg concentrations themselves, as was recently attempted for the anomalous iceberg year 1947 (Soule and Challender, 1949).

North Atlantic Pressures and Temperatures

From the examination of the stability of the apparent control of the iceberg severity off Newfoundland reflected in the pressures and temperatures of the North Atlantic and adjacent areas, it would appear that while the pressure fall: Bergen to Stykkisholm has ceased, it may be said to denote an inflow of air into the Arctic that is followed by an outflow over Baffin Bay and Davis Strait (west side), the pressure fall: Belle Isle to Ivigtut contines to reflect the northerly air flow along the Labrador coast which materially affects the number and speed of bergs that drift southward to Newfoundland waters, as was initially indicated by Smith for the 47-year period ending with 1925/26.

Similarly, the preceding temperatures at St. John's, Bermuda and Uppsala in combination, continue to reflect an influence on the iceberg severity off Newfoundland the following late spring and early summer, as originally indicated by Groissmayr (ibid.) for the same 47-year period:

1879/80-1925/26, which when employing the full interval: December-March for all three terms rather than December-February for St. John's and Bermuda and March for Uppsala, as was done initially, turns out to be more stable, the differences in r from the first half to the second half of the period being smaller with December-March values than with the components of this interval (Table 3).

TABLE 3

Relations of the Ice off Newfoundland with St. John's, Bermuda and Uppsala Temperatures Based on December-March values Compared with Relations with St. John's and Bermuda based on December-February and Uppsala on March only values, shown by the Correlation Coefficients, r.

		St. John's		Bermuda		Uppsala	
Period	n	D-M r	D-F r	D-M r	D-F r	D-M r	March r
1879/80-1948/49	70	-0.46	-0.44	0.40	0.34	0.55	0.57
1879/80-1913/14	35	-0.59	-0.74	0.45	0.44	0.54	0.51
1914/15-1948/49	35	-0.34	-0.19	0.35	0.23	0.58	0.63

The joint influence reflected by the Belle Isle-Ivigtut pressure fall and the temperatures above, in terms of their multiple correlation coefficient, m.c.c., is, R = 0.62.

As a test of the indicated control of the ice reflected by the pressures and temperatures above, the values of the ice departure for the recent 23-year period: 1927-1948, were computed with the aid of the formula based on data to 1926, inclusive:

ICE (Newfdld) = + 0.13 Δ PRES. (Belle Isle-Ivigtut) - 0.27 Δ TEMP. (St. John's) + 0.25 Δ TEMP. (Bermuda) + 0.17 Δ TEMP. (Uppsala)*

They are shown together with the actual departures in Table 4.

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* See footnote page 7.

As might be expected from the evidence of marked stability of the relations of the December-March temperatures and the Belle Isle-Ivigtut pressure fall, with the ice (Table 1, 3), there is a marked agreement between the computed and the actual departures also in recent years (1927-1949). Of the 23 cases involved, disagreement as to sign between the computed and observed departures occurred in only six (1929, 1933, 1944, 1945, 1946 and 1949), and of the 10 cases with a computed departure in excess of $\pm$ 1.0 disagreement occurred in none, while the over-all agreement in terms of the correlation coefficient for the entire 23-year period is r = 0.69.

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* The individual correlation coefficients, r, for the periods ending with 1925/26 are as follows:

Ice with	Belle Isle - Ivigtut	pressures,	r = 0.47
"	St. John's	temperature	-0.47
"	Bermuda	"	0.49
"	Uppsala	"	0.45
Belle Isle - Ivigtut pressures with	St. John's	"	-0.43
"	Bermuda	"	0.44
"	Uppsala	"	0.70
St. John's temperature "	Bermuda	"	-0.39
"	Uppsala	"	-0.27
Bermuda temperature "	Uppsala	"	0.48

TABLE 4

Computed and Observed Departures (Δ) from the Long-Term Normal (1880-1926) in the Iceberg Severity off Newfoundland: 1927 - 1949, on Scale of 10.

Year	Computed Δ	Observed Δ
1927	0.1	0.0
8	0.2	0.8
9	-0.2	4.2
1930	2.1*	0.6
1	-1.8*	-2.8
2	0.4	0.8
3	0.1	-1.1
4	1.5*	1.0
5	0.7	2.7
6	-2.0*	-2.8
7	0.6	0.6
8	1.1*	1.8
9	1.1*	1.8
1940	-2.8*	-4.7
1	-1.7*	-4.7
2	-2.4*	-2.4
3	1.2*	2.4
4	-0.2	2.0
5	-0.7	3.9
6	-0.3	0.1
7	-0.7	-2.0
8	0.8	1.1
9	1.0*°	-2.1

* Values in excess of ± 1.0
° Based on incomplete data

DISCUSSION

The examination above of the conditions presumed to reflect the control of ice off Newfoundland indicates that the general premise about changes in the North Atlantic and adjacent areas affecting the following ice off Newfoundland is true. Of the variously derived relations by Smith and Groissmayr, only the Bergen to Stykkisholm October-January pressure fall appears to have ceased to be significant. In rejecting the latter, we must not think, however, that greater inflows of air into the Arctic by

way of the northeastern North Atlantic no longer lead to greater outflows over Baffin Bay, etc. The marked correlation of the Uppsala temperature which may be assumed to measure the northeastward flow into the Arctic by way of Scandinavia, with the following ice off Newfoundland, has remained unchanged (Table 2). We may only conclude that changes in the Bergen to Stykkisholm pressure fall in October-January have not continued to lead to changes in the outflow of cold air the following spring, etc., over Baffin Bay, probably because of the marked alteration in the pressure field in recent decades over the northeastern North Atlantic (Scherhag, 1938).

METHOD OF COMPUTATION AND DATA

The method used here for examining the relation of the ice off Newfoundland to the preceding pressures and temperatures of the North Atlantic and adjacent areas, initially suggested by Smith and Groissmayr, was to compare the variations from the mean in the temperatures, etc., with the variations from the mean in the ice, employing both the linear correlation coefficient, r, and the deviations.

In the original investigation by Smith (ibid.) the months with the larger values of the coefficients were given twice the weight of the months with smaller values of r, rather than derive a regression equation with its undue implication of exactness of the relationship.

It is equally true, however, that where the months in question adjoin each other, the general fluctuation of the relation with time may also involve an increase in the association of the months with smaller values of r and a decrease for the months with the larger values of r. Accordingly, we may wish to treat all months with a significant degree of correlation, as of equal weight.

Thus, it was found by combining the unweighted December to March monthly data of the Belle Isle to Ivigtut pressure fall, its relation with the ice appeared actually closer, the obtained values of r for the unweighted and weighted series (1882-82/1948/49, n = 67) being r = 0.53 and r = 0.47, respectively.

DATA AND ACKNOWLEDGMENTS

The data used in this study were obtained from official publications and by personal communication. The author wishes to express his warm thanks to the officials of the

meteorological services of Canada, Sweden, Denmark and Bermuda for kindly providing the more recent meteorological data used in this study and to the Officers of the International Iceberg Patrol for the iceberg counts of more recent years.

I am also indebted to Mr. Joseph G. Galway and Miss Patricia McMillin for carrying the detailed computations of this study.

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COMMENTS

on

Schell, I. I.: On foreshadowing the severity of the iceberg season south of Newfoundland. W.H.O.I. Technical Report

by Floyd M. Soule

Considering only the transportation facilities afforded bergs during their final season's travel from Davis Strait along the Labrador coast to Newfoundland, and assuming that these facilities are provided by the atmospheric circulation, the author has examined several indicators of this circulation and has related them to the number of bergs appearing in Newfoundland waters the following spring and summer. A strong outflow of air from the Arctic was considered to have been indicated directly by the barometric pressure difference between Belle Isle and Ivigtut, and indirectly by the pressure drop from Bergen to Stykkisholm and by the air temperatures at Bermuda and Uppsala, and at St. John's with negative sign. The data examined covered the periods of the last 67 years for the Belle Isle-Ivigtut difference and the last 70 years for the other indicators. Each indicator was examined for the period as a whole and for the first and last halves of the period. The Bergen-Stykkisholm data showed a poorer relationship during the second half than during the first half, as did the St. John's data, while the Uppsala data showed an improving relationship. The author has rejected the Bergen-Stykkisholm difference as an indicator and, considering the changes in St. John's and Uppsala to be compensating, has used the expression:

$$+ 0.13 \Delta(\text{Belle Isle-Ivigtut}) - 0.27 \Delta(\text{St. John's})$$

$$+ 0.25 \Delta(\text{Bermuda}) + 0.17 \Delta(\text{Uppsala})$$

to give the departures from normal (4.8) of the iceberg crop on a scale of 10. In this, both pressures and temperatures for the equally weighted months of December through March immediately preceding the iceberg season have been used. When applied to the seasons of 1927 through 1949 this formula results in computed values which depart from observed values by 1.0 or more in 12 of the 23 years. Of those 12 cases 7 agree as to the sign of the computed and observed departures from normal. Thus, while this cannot be regarded as a forecast method there is some improvement over the Smith formulae.